Committee on Resources

Subcommittee on National Parks and Public Lands

Testimony

STATEMENT OF

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BEFORE THE

SUBCOMMITTEE ON NATIONAL PARKS AND PUBLIC LANDS

COMMITTEE ON RESOURCES

U.S. HOUSE OF REPRESENTATIVES

JUNE 29, 1999

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(CDC). Thank you for your invitation to testify concerning the risks of exposure to hantaviruses for visitors on Channel Islands National Park, California. In my testimony I will summarize data from the published scientific literature and from CDC studies that will shed light on the factors which contribute to the risk of acquiring hantavirus pulmonary syndrome (HPS) in North America. I will also discuss CDC's collaborative efforts with the National Park Service (NPS) and State health departments which led to recommendations for prevention and control of hantavirus infections.

Hantaviruses

Hantaviruses are rodent-borne disease agents that exist in rodent populations throughout the Americas and in much of Asia and Europe. Currently, at least 27 hantaviruses are recognized in Asia, Europe, and the Americas. Most of these viruses have been recognized within the last six years and, undoubtedly, many more await discovery. Each virus is generally associated with a single primary rodent host species. All adequately studied host species are members of a single rodent family-called the Muridae-which is extremely diverse, containing over 1000 species. Evidence indicates that these viruses have been co-evolving with their rodent hosts for millions of years, implying that these viruses have been present in our environment since before recorded history.

Hantavirus Disease

Human disease likely caused by hantaviruses was described at least as early as World War I, and was responsible for illness in over 3000 United Nations troops during the Korean conflict. However, it was not until 1976 that a hantavirus, Hantaan virus, was first isolated from a striped field mouse captured along the banks of the Hantaan River, near the border between North and South Korea. The form of hantavirus disease present in Europe and Asia is called hemorrhagic fever with renal syndrome (HFRS). Hantaviruses have a significant impact in Asia, where they may cause 200,000 cases of HFRS per year, with a mortality of 5-15%.

Hantavirus disease was virtually unknown in the Americas until 1993, when a physician at the Indian Health Service (IHS) in New Mexico reported that two previously healthy young people had died from acute respiratory failure. Over the next few days, additional cases were identified by the State medical examiner's office and by other IHS physicians. Fortunately, CDC's application of sophisticated molecular biologic techniques led to the rapid identification of a previously unrecognized hantavirus as the cause of this illness, although it took months to actually isolate the virus. While the symptoms and effects of this disease were quite different from illness seen in Europe and Asia, scientists were able to quickly identify and characterize the new virus and to implicate its primary host, the deer mouse, *Peromyscus maniculatus*. The virus is now called Sin Nombre virus (SNV), and the disease is hantavirus pulmonary syndrome (HPS).

Three additional hantaviruses, hosted by three other species of rodents, also are recognized as agents of HPS in the United States. New York virus, hosted by the white-footed mouse (*Peromyscus leucopus*), was

associated with two cases of HPS acquired in New York; Black Creek Canal virus, carried by the cotton rat (*Sigmodon hispidus*), has caused one case in south Florida; and Bayou virus, hosted by the rice rat (*Oryzomys palustris*), has been responsible for three recognized cases in Louisiana and Texas. Since the recognition of HPS in the United States, outbreaks of disease have been confirmed in Canada, Argentina, Chile, Paraguay, Uruguay, and Brazil, and hantavirus-infected rodents have been found in Peru, Bolivia, Venezuela, Costa Rica, and Mexico. At least 23 hantaviruses have been described in the Americas, each associated with a single primary host species; about half of these are known to cause HPS in humans, although the virus appears to have no harmful effect on its rodent host.

HPS is an acute respiratory illness, characterized by onset of fever, severe muscle aches, and malaise, which may rapidly progress to acute respiratory distress requiring intensive care and supplemental oxygen. The case fatality rate in the United States is 43%. As of June 24, 1999, CDC had confirmed 217 cases of HPS in 30 states. Over 70% of cases originate from rural areas, where exposure to rodents near the home was believed to be important in infection.

SNV, hosted by the deer mouse, is the agent responsible for the great majority of HPS cases in North America. The deer mouse is one of the most common and widespread small mammals in the United States. It occurs in almost every dry land habitat, and the geographic range of this species extends throughout the entire continental United States except for the Southeast and the Atlantic seaboard. Sampling programs have detected evidence of infection with SNV in this species throughout its range, and HPS cases have been reported in much of the range, although the greatest number of cases are reported from the western United States. Small differences in the genetic structure of SNV occur among geographic locations throughout the United States. Not unexpectedly, the genetic structure of SNV on the Channel Islands is slightly different from that of mainland strains of SNV. Many of these different strains of SNV have been shown to cause HPS, with no discernable differences in the clinical signs and symptoms. Although no cases of HPS have occurred on the Channel Islands, there is no reason to believe that human infection with SNV from Channel Islands deer mice would not result in typical HPS.

Transmission of Hantaviruses

Each virus is associated with a single primary rodent host species, in which it establishes a chronic, asymptomatic infection that involves the shedding of infectious virus into the environment in rodent urine, feces, and saliva. These characteristics are key to the transmission of the virus both to humans, which occurs most frequently by inhalation of infectious aerosols, and among rodents, which may be by a variety of mechanisms, including bites. Theoretically, any mammal species that comes into contact with an infected host could become infected. Indeed, chipmunks, squirrels, dogs, cats, and coyotes have been found with evidence of infection. Nevertheless, all evidence indicates that, as a result of millions of years of co-evolution, only the specific natural host is likely to develop a chronic infection and shed large quantities of virus into the environment. When other species are infected, they appear to quickly develop antibody and clear the virus. These species are therefore considered to be "dead-end hosts," unlikely to pass the virus on to humans or other mammals.

Available evidence indicates that the most frequent mechanism of infection for humans is the inhalation of infectious aerosols produced when rodents urinate. However, other routes of exposure are possible. Infection may occur via direct contact with rodents or rodent-contaminated objects that results in introduction of virus through broken skin or mucous membranes, or by ingestion. The stability of the virus in rodent excreta deposited on environmental surfaces depends on many factors, including temperature, exposure to light, and rodent diet. In general, viral particles on environmental surfaces remain infectious for only a few days. In addition to the danger posed by direct contact with these surfaces, it is possible that secondary aerosols created by activities such as cleaning may be responsible for some human infections. Rodent bites may also be an efficient mechanism for human infection, and cases of HPS have been associated with handling deer mice. Human-to-human transmission of hantaviruses in North America has never been documented. Although the deer mouse is a rural species, it frequently seeks shelter in structures used by humans and will take up residence in homes, garages, outbuildings, trailers, or motor vehicles. Analysis of case histories suggests that circumstances favoring the creation and persistence of infectious aerosols are particularly risky. Such a situation would occur with human entrance into closed, indoor spaces, with minimum circulation of air, and an active infestation of infected rodents. Outdoors, natural circulation of air quickly dissipates aerosols, and the virucidal properties of natural ultraviolet light from the sun further reduce the survival of virus, making exposure less likely.

Risk Prediction Through Rodent Monitoring

The risk of human disease is proportional to the frequency with which humans come into contact with infectious rodents. Two measurable properties of host rodent populations that may help to quantify relative risk are the relative numbers of mice (usually expressed in terms of population density), and the prevalence of infection in these populations (estimated as the proportion of captured and tested mice that have antibody reactive with SNV). CDC-sponsored long-term studies have shown that hantavirus infection in host populations is a dynamic process. Both population densities and antibody prevalences vary from site to site and can change markedly from season to season and from year to year. Population densities may vary 10-fold within periods of two or three months. Dramatic increases in rodent abundance may occur in response to unusually favorable environmental conditions. One example is the El Niño southern variation, which occasionally brings increased rainfall to typically dry areas of the southwestern United States. These population increases are usually short lived and followed by declines as rodent numbers exceed the capacity of the environment to support them. Prevalences of hantavirus infection in deer mouse populations are typically 10 to 15%, but have occasionally reached values exceeding 60% for brief periods at specific sites where monitoring was done in Arizona, Colorado, New Mexico, Montana, and California. These increased prevalences of hantavirus infection in rodents often follow periods of high rodent population density. Infrequently, appropriate environmental conditions result in the simultaneous occurrence of both high densities and high prevalence of infection. This combination, which appears to be occurring this year in some rodent populations in Colorado and New Mexico, results in a higher absolute number of infected mice and implies that there may be a higher risk of infection for humans. A higher number of HPS cases is being reported in the Southwest this year and supports this interpretation.

The goal of our long-term rodent studies is to identify the specific environmental factors that lead to

increased densities of rodent populations and to increased risk to human populations, and thereby develop a predictive model of disease risk. Since it is impractical to have rodent monitoring programs in every area where deer mice live, we hope to ultimately be able to use satellites to detect patterns on the ground such as relative greenness of vegetation, to predict relative risk over wide geographic areas.

Prevention and Control Measures

Ribavirin, an antiviral drug that may be effective against some types of viruses, including certain other hantaviruses that do not cause HPS, is currently being studied in persons with HPS by the National Institute of Allergy and Infectious Diseases. Currently however, there is no effective treatment for HPS, and no vaccine will be available in the near future. Therefore, prevention is the primary tool for lessening the impact of this disease. The most effective way to decrease the risk of HPS is to limit human exposure to rodents and their wastes. The primary method of limiting exposure should be to keep rodents out of structures for human habitation by rodent-proofing, trapping, and poisoning if necessary. Simple, inexpensive methods of rodent-proofing have been developed and tested during collaborative studies by the CDC and the NPS. The methods were shown to reduce rodent infestation rates by approximately 90% in rustic cabins at national parks in the eastern and western United States. A recently published manual, developed by the NPS, is the best available source on rodent-proofing techniques and is cited in CDC recommendations. Precautions during clean-up of rodent-infested areas are also important, and detailed guidelines are available from CDC, NPS, the State of California, and other State and local health departments.

Outdoor exposures are infrequent, but they do occur. Recently, two cases of HPS were associated with catching, handling, and being bitten by a deer mouse. Prevention of these kinds of exposures are particularly relevant to the national parks, and getting prevention information to visitors should be a priority. Specific prevention and control measures include the following: avoid contact with mice, their wastes, or their nests; maintain a clean campground; keep food in rodent-proof containers; avoid camping in areas that have evidence of rodent activity; and sleep off the ground or in a tent that can be sealed. CDC has published numerous public education materials outlining general prevention and control measures, including pamphlets, posters, and videos.

Preventing Emerging Infectious Diseases

As the nation's disease prevention and control agency, it is CDC's responsibility to provide national leadership in the public health and medical communities in a concerted effort to detect, diagnose, respond to, and prevent illnesses such as HPS. This task is an integral part of CDC's overall mission to monitor the health of the U.S. population.

According to the Institute of Medicine's 1992 report, *Emerging Infections: Microbial Threats to Health in the United States*, emerging infections are new or reemerging infections whose incidence in humans has

increased within the past two decades or whose incidence threatens to increase in the near future. Hantaviruses provide an excellent example of emergence, and vectorborne and zoonotic diseases is a target area in CDC's recently released plan, *Preventing Emerging Infectious Diseases: A Strategy for the 21st Century*. The plan describes CDC's approach to combat today's emerging diseases and prevent those of tomorrow, and it focuses on four goals, each of which has played a role in CDC's response to hantavirus: disease surveillance and outbreak response; applied research to develop diagnostic tests, drugs, vaccines, and surveillance tools; infrastructure and training; and disease prevention and control. Copies of this CDC plan have been provided to the Subcommittee.

Collaborations

Preventing human disease caused by hantavirus requires close collaboration among both public and private partners. CDC has worked closely with State health departments and with NPS to measure the risk of hantavirus disease throughout the United States and to develop and implement strategies to prevent human exposure. These efforts have included large-scale studies of rodent populations throughout the United States and collaboration with State health departments to develop reporting procedures and to respond to cases of hantavirus disease. Recommendations for reducing the risk of exposure to hantaviruses were developed with the participation of several State health departments and were published in CDC's *Morbidity and Mortality Weekly Report (MMWR)* in 1993. CDC's recommendations and guidelines have been widely distributed to health care professionals and the public through State and local health departments and by NPS.

Beginning in 1994, CDC and NPS collaborated in an extensive survey of hantavirus infection in rodents in national parks, as well as in the development and testing of methodologies to reduce the risk of human exposure by excluding rodents from Park Service cabins and trailers. CDC's hantavirus web page provides links to the NPS web page for details on how to exclude rodents from homes and other structures. In California, CDC investigators collaborated with State officials in a state-wide survey of hantavirus infection in rodent populations. CDC provided serologic testing of rodents from the Channel Islands in 1994 that indicated an unusually high prevalence of hantavirus antibody on some islands and participated in follow-up studies in 1995 and 1996 that demonstrated much lower prevalences on the same islands. These studies were published in CDC's *Emerging Infectious Diseases* journal in 1997.

When high numbers of rodents and high prevalences of antibody to hantaviruses were observed in Channel Islands National Park in 1994, little was known about the relationship among rodent numbers, antibody prevalence, and the risk of human disease. CDC-sponsored studies, including the National Parks survey and long-term studies of rodent population dynamics in the southwestern United States, were initiated to address this question.

CDC also collaborated with four universities-the University of Arizona at Tucson; Yavapai College in Prescott, Arizona; Colorado State University in Fort Collins, Colorado; and the University of New Mexico at Albuquerque-to longitudinally study hantavirus reservoir populations in Arizona, Colorado, and New

Mexico. Last week, CDC published some more recent data in the *MMWR*, along with recommendations to renew attention to hantavirus risk reduction and to increase physician awareness of HPS. Copies of this *MMWR* have been provided to the Subcommittee.

Conclusions

Hantaviruses are widespread and very common throughout rural areas of the United States. Humans have probably coexisted with the wild mice that carry these viruses for hundreds of years but have been unaware of their presence until recently. The incidence of HPS in the United States is very low; overall risk to the public is low as compared with many other diseases, but the disease has a high mortality. Our newly gained knowledge of the virus and its mechanisms of transmission provides us with the advantage of being able to recommend to the public that they avoid specific high-risk activities and, thereby, decrease the occurrence of hantavirus disease.

Deer mice are a natural and inextricable component of natural ecosystems, forming an important part of the food web. Their eradication from large natural areas is neither feasible nor desirable. The closing of specific geographic areas to the public has never been recommended, even during outbreaks of hantavirus disease. Nevertheless, prevention methods such as public education can be effective, especially for specific populations that are easily accessible, such as visitors to specific national parks, and these programs should be vigorously pursued.

Thank you very much for your attention. I will be happy to answer any questions you may have.